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COORDINATION OF TRANSPORTATION OPERATIONS BY 3PL BASED ON REAL-TIME CLOUD DATA

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Purpose: Main aim of the following paper is to present the conception of logistics coordination from the point of view of transportation actions from the perspective of the international 3PL company.
Design/methodology/approach: In the paper used the case study based on the case of chosen international 3PL, where the distribution network was analyzed.
Findings: 3PL is able to support the transportation planning operation in the considered distribution network by using a developed cloud-based infrastructure that supports demand forecasting tool and transportation planning.
Originality/value: Paper connects the one function of logistics coordination – transportation planning – with the demand forecasting tool and the issues of 3PL. It is also shown the case study with implemented solution based on cloud infrastructure to support the transportation operations.

Keywords: 3PL, logistics service provider, distribution network, transportation, logistics coordination.

Category of the paper: case study.

1. Introduction

Transportation is considered one of the most energy-consuming activities in the whole supply chain (Halldorsson et al., 2020) but on the other hand, it is also one of its main components (Paul et al., 2020). An appraisal of prior studies on the types of logistics services indicated that the most common service attributes were related to warehousing, logistics value-added services, information service, financial service, and transportation (Kuo et al., 2020). Transportation is one of the most common outsourced functions in the supply chains (Multaharju, Hallikas, 2015) and also is one of the most visible operations in logistics (Lin, 2008). Operation connected with breaking the distance barriers and responsible for providing the goods in the proper places and time.

Transportation in the context of order delivery or distribution is the primary function of logistics in a supply chain. The growing demand for this type of service gave birth to the emergence of 3PL (Robas et al., 2020). Over the two last decades, the logistics service providers and logistics state the essential to develop the supply chains and logistics networks (Ashrafian et al., 2019). 3PL could be defined as an external supplier that performs or manages the performance of all or part of a company's logistics functions (Langley, 2020). What is important, the 3PL should also be able to create value in logistics processes. In the following article, the 3PL will be used repeatably with a logistics service provider (LSP) and third-party logistics. The author is aware of some literature differences between LSP and 3PL but decided to not divide these two creations separately. Companies that outsourced the logistics activities to 3PL could expect a more efficient and cost-effective process than the others (Robas et al., 2020).

Even in the nowadays conceptions like omnichannel distribution, the transportation issues like delivery efficiency and costs are the most exploited areas (de Borba et al., 2020; Lin et al., 2022; Mishra et al., 2021). This trend (which is still very popular in different markets, even in the case of groceries (Ehrler et al., 2021)) is also seen in the different types of multichannel distribution like online-to-offline (O2O) (Lafkihi et al., 2019). The other factors which are also still important in contemporary logistics are location problems, vehicle routing, and last-mile delivery (Bayliss et al., 2020; Bergmann et al., 2020). Current turbulent surrounding (implicated for example by COVID-19 pandemic) also has a strong impact on the transportation industry (Hu et al., 2022). The following article connects the issues of 3PL activity in nowadays market in the conception of logistics coordination with a special emphasis on transportation operation. Paper also try to answer to the following research questions:

RQ1: Which kind of process flow is needed for cloud solution for support the transportation operation in distribution network by 3PL?

RQ2: Which kind of data are needed for support the 3PL actions in the case of transportation planning?

and verifies the following hypothesis:

H1: 3PL is able to support the transportation planning operation in the considered distribution network.

Research questions, hypotheses, and methodology are discussed in more detail in the methods section and they were elaborated based on the author's conception connected with logistics coordination (the logistics coordination concept is shown, among others, at Kmiecik (2022)). Which assumes the 3PL as the main node to taking the function of logistics coordination in distribution networks using a mechanisms (market, social and hierarchic) of network coordination and conducting the actions connected with demand management, transportation planning, inventory management, resource planning, demand forecasting in the support of contemporary technology achievements.

2. Logistics service providers (3PL) in nowadays market

2.1. Transportation coordination by 3PL

Nowadays, we are dealing more and more often with the one delivery day standard in transport operations (Grzelak et al., 2019). Logistics operators are struggling with the need to meet the increasingly demanding order deadlines, especially in the area of road distribution. As highlighted by some authors, 3PL, through appropriate transport planning, can reduce flow times and reduce inventory levels (Wang et al., 2020a) by increasing the speed of reaction and eliminating the need to maintain high safety stocks. Companies outsourced not only the traditional logistics services but also managerial activities, so logistics providers have developed both services to fulfill the market requirement (Fabbe-Costes et al., 2009) and still looking forward to gathering the new skills and offering the new services to their contractors. Usage of 3PL could lead to reducing the disruptions in logistics in a more easy way (Nel et al., 2018). Coordinated actions in this area may also lead to the shortening of transport routes and bring savings (Wang et al., 2020b). Currently, an increasingly important criterion is also the ability of the operator to meet the assumptions of sustainable development, CO2 emissions, and adaptation to modern solutions related to, for example, Smart Cities in the area of urban logistics in the long term. (Kramarz et al., 2020).

The trend of e-commerce did not reduce the meaning of brick-and-mortar point of sales (POS) (Lin et al., 2022), so the traditional transportation issues are still very important even in reality when literature focuses mostly on last-mile deliveries. Transport operations, and in particular the ability to carry them out efficiently and flexibly, play a significant role in the coordination of the distribution network.

In addition, many companies from the 3PL group provide transport services. There are so many of these enterprises that the problem becomes the choice of the right operator to provide transport services - hence, numerous mathematical models appear in the literature, which is used to assess and select the operator. According to the research (figure 1) in about 90% of cases, the 3PL are treated as a member of supply chains, and in 80% of cases, the supply chain members thought that they need to integrate with the other chain nodes. What is interesting only about 50% of supply chain members think that 3PL contributes to chain performance.

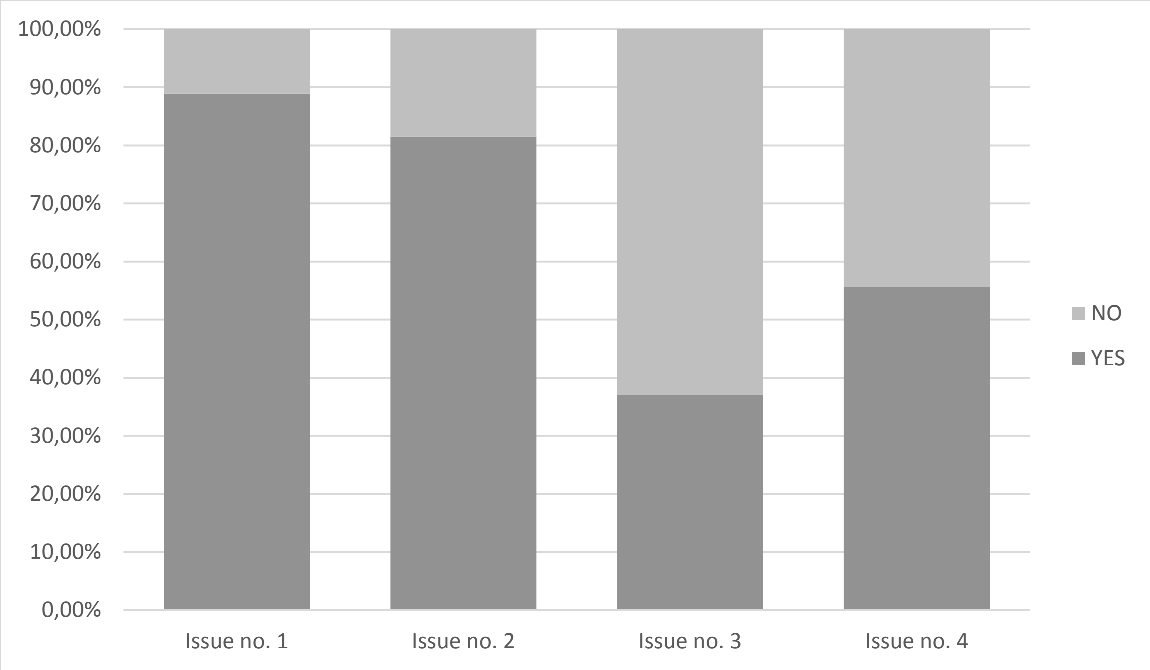

Figure 1. Logistics services providers in supply chain.

Source: (Fabbe-Costes et al., 2009).

It is hard to achieve coordination in the supply chain while considering the transportation costs separately to the whole operational activity and the lack of coordination between transportation companies leads to insufficient logistics efficiency (Hu et al., 2022). The interesting model presented by Yayla et al. (2015), distinguishes three main criteria for assessing the operator's ability to perform transport services efficiently: possibility of developing sustainable cooperation, which mainly manifests itself in generating low transport costs, good financial condition, correct reputation and showing similar values between enterprises; ensuring an appropriate level of service quality, which is mainly manifested in keeping the on time delivery ratio at a high level, speed of response and reliability of deliveries and the ability to continuously improve, mainly related to technological sophistication, solid infrastructure and the ability to optimize operations

Undoubtedly, these criteria must be considered when choosing an operator that will be able to coordinate the company's activities in the distribution network. Of course, not every operator who is able to provide transport services can coordinate the flows, but the ability to plan and organize transport operations is, according to the author, one of the necessary requirements for the implementation of the assumptions resulting from logistic coordination.

2.2. Contemporary challenges of 3PL in transportation operations

Transportation is stated as one of the main components of the operational aspect of supply chain activities (Paul et al., 2020). Even in the nowadays market usage of effective transportation routes provides the possibility of achieving competitive advantages for companies (Abbasi et al., 2020). Driver shortage may negatively affect an LSP's competitiveness. It could influence the price and on-time delivery; as driver pay increases due to the shortage, it significantly impacts the fleet. Transportation capacity shortage is a significant problem in the modern transportation and logistics industry (Wang et al., 2020c). Contemporary transportation needs to handle massive, high-frequency volumes characterized by short lead times and a high level of fluctuation (Lafkihi et al., 2019).

One of the most important challenges is adjusting the transportation structures to last-mile deliveries due to rapid urbanization and the development of mass transit systems (Halldorsson et al., 2020; Shu et al., 2021).

3PL which focuses on standard solutions may lose significant market share shortly, management-related 3PL actions seem to be the time more existing by new external competitors. Digitalization enables the forward or backward combination of 3PL customers and suppliers when they establish their services. Digital technology reduces labor cost by streamlining data imprison and dropping error (Ruthramathi, Sivakumar, 2020). Digitalization and technology is also one of the most common issues in the transportation industry (the rest are environment, government, roads, financial, cold chain, and legal) (Mangla et al., 2019).

Different issue, connected also with digitalization is Big Data in transportation. Handling with Big Data is different in the comparison of standard data because of three main factors: data volume, data velocity and data variety (Torre-Bastida et al., 2018). Big data analytics allows the processing of voluminous data from multiple sources to create meaningful insight not only on customer satisfaction but, among others, transportation management (Jagtap et al., 2020). Innovation can reinforce competitive advantage for companies in markets where customer preferences change rapidly, where differentiation is limited, and where competition is intense (Lin, 2008).

One of the most trendy issues in transportation is the usage of Collaborative Transport Management (CTM). CTM could be defined as the collaboration in the transportation area, notably among truckload transportation. The goal of the CTM is the "win-win-win" outcomes to all the parties involved in the collaboration and it is aimed to reduce inefficiency, avoid logistics bottlenecks as well as to provide mutual benefits to all parties (Sitadewi et al., 2018). CTM was initially developed to complement CPFR (Collaborative Planning, Forecasting, and Replenishment).

The fact that logistic operators can coordinate and perform transport operations in distribution networks is influenced, among others, by the fact that these enterprises usually either have TMS (Transport Management System) class systems or have an easy ability to adapt such systems to their structures (Melanici et al., 2013), Also, a popular solution is information and communication technologies (ICT) which support transportation in the field of intelligent cargo, intelligent containers, and intelligent trucks (Liu, Ke, 2022; Nemoto, Tezuka, 2002; Tran-Dang et al., 2022). Transportation cyber-physical systems (TCPS) integrate cyber systems and physical systems using communication networks, and they interact with each other to support various applications (Deng et al., 2020) and they are also shown as a future of transportation and is connected with the rapid development of IoT (Internet of Things) provides the opportunity to solve some common problems in transportation connected with decision-making and information asymmetry (Xu et al., 2019). Contemporary solutions which support the transportation activity should be the answer for fragmented and fluctuant volume, high-speed flow, variety of delivery points, direct to customer requirements and should act in the fierce competition, low margin environment, strict constraints and regulations and the problem of drivers shortage (Lafkihi et al., 2019). Robotics is also commonly seen in transportation (Jagtap et al., 2020) like the solutions connected with sharing economies, crowd shipping, horizontal cooperation, dynamic delivery systems, and online marketplaces (Lafkihi et al., 2019).

The solution which is also really important in nowadays companies' activities is cloud technology. Cloud computing plays an instrumental role in this endeavor by storing, processing and transferring the enormous amounts of data generated by various types of said sensors, in the cloud instead of the connected devices (Agalianos et al., 2020). Cloud solutions usually supports the information and ICT in transportation (Deng et al., 2020; Tran-Dang et al., 2022). Cloud-based real-time data provides information regarding to location of objects, parameters and transportation surroundings (Agalianos et al., 2020). Traditionally, when using a server-based architecture, application developers need to establish a cloud server instance according to their computing requirements (Deng et al., 2020). One of the most important features of cloud computing is sharing the configurable resources among many users (cloud clients) flexibly with minimal management efforts (Xu et al., 2019). Google Cloud Platform (GCP) is stated as one of the most suitable software to cloud computing also in the case of transportation issues (Deng et al., 2020).

3. Methods

The research paper consists of a case study conducted on the chosen international 3PL company with showing the implementation case of a cloud-based solution for support transportation planning proposed by the author (figure 2).

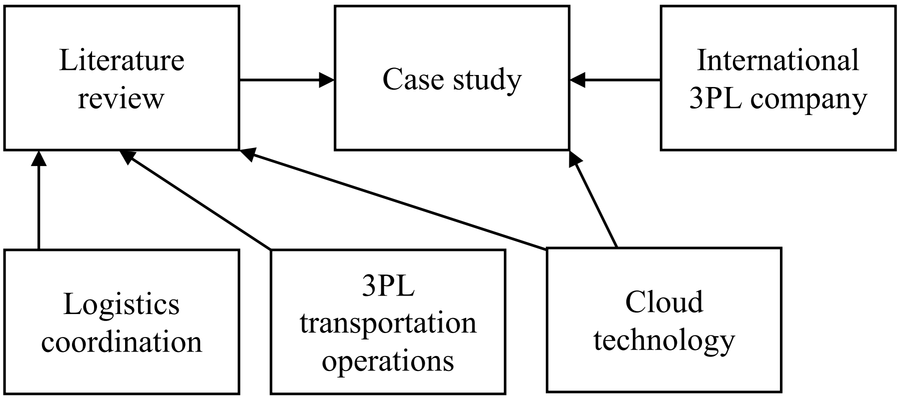

Figure 2. Main research steps.

Source: own elaboration.

Proposed solution based strictly on data analysis. This kind of solutions in the conditions of transportation improvement are described as one of the most important issues (Shu et al., 2021). Proposed solution and case study construction is shown at figure 3.

The case study focuses on 3PL company which is international logistics service provider and acting the logistics outsourcing activities for the manufacturers in distribution networks. The chosen 3PL provides goods directly to middlemen, customers or to POS (Points of Sales) – depends on the distribution network. Also, in one network, 3PL could provide the goods and services to the few kinds of recipients – depends also on network specification and configuration. In the chosen case the 3PL the case of road transportation services to POS is analyzed. Currently, the 3PL actions in the area of transportation are supported by TMS (Transport Management System) which is used for transportation planning and fleet control. Information which are taken into consideration are the information about quantity and capacity of own transportation fleet. So the main considerate issue in this case is the current information about road fleet capacity. TMS data, in the author proposition, are supported by demand forecasting tool to achieve the planned result of tool for transportation coordination. Demand forecasting tool is the concept created by the author (more specific information could be found, among others, at Kmiecik (2022) and Kramarz and Kmiecik, (2022)) which is under the implementation in the few distribution network where chosen 3PL provide the services. Modified version assumed the TMS support will be presented in the further part of following paper.

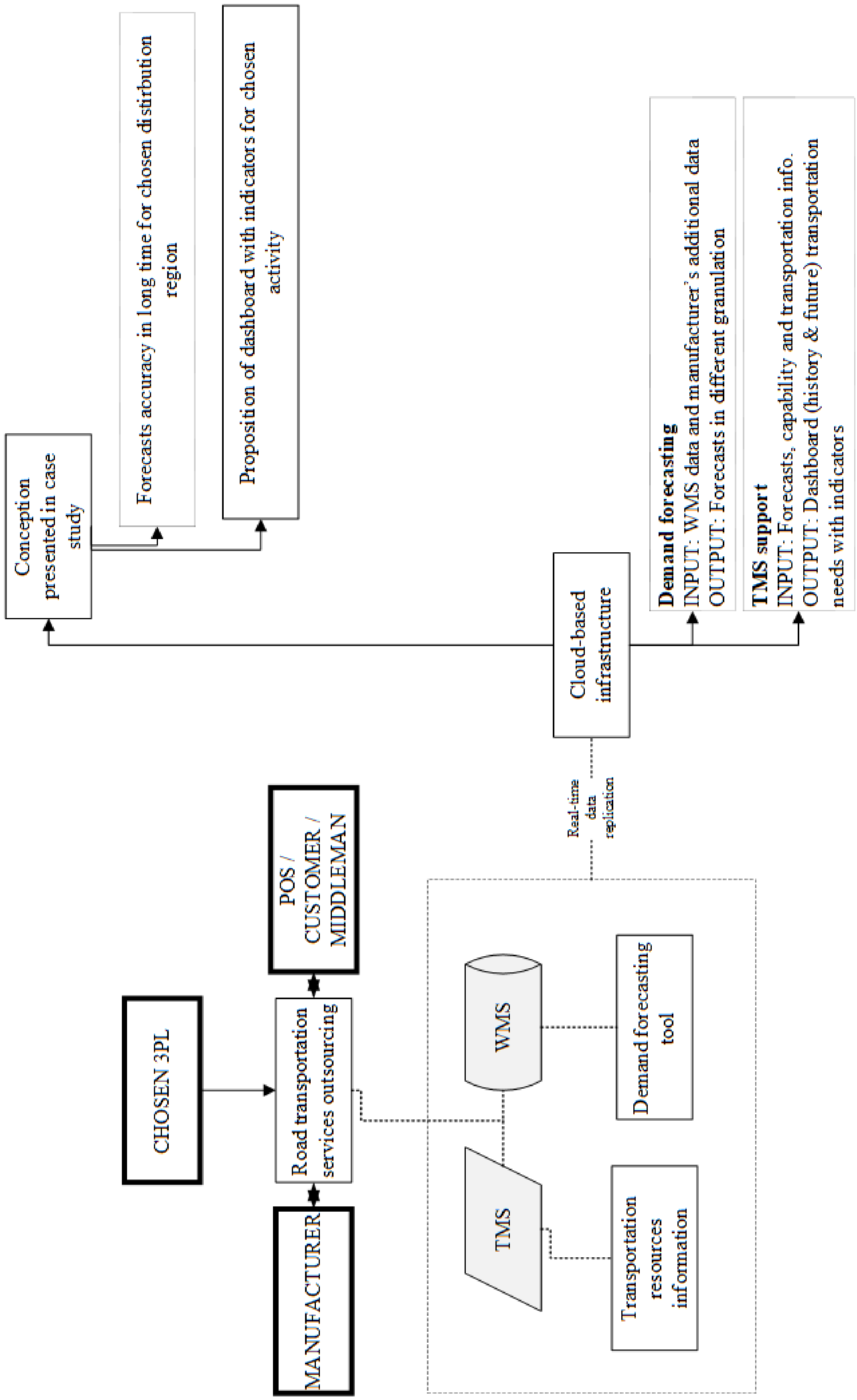

Figure 3. Case study construction.

Source: own elaboration.

Whole tool, proposed by the author, will be settled in the cloud-based infrastructure. The chose of this kind of technology will be dictated by its functionality and easy access to real-time data which support the fast decision-making process. Data set consist of daily data about regions (postal codes) of distribution, quantities of distributed pallets (e-pal) and dates of movements. Data are limited only for one country of distribution (Poland), one point of distribution (one of warehouse of 3PL), one customer (manufacturing company which provide goods to POS) and one type of goods according to transportation requirements (goods which could be handled on e-pal without additional requirements about transportation temperature). General data set consists of data from January 2012 to June 2021 and is presented at figure 4.

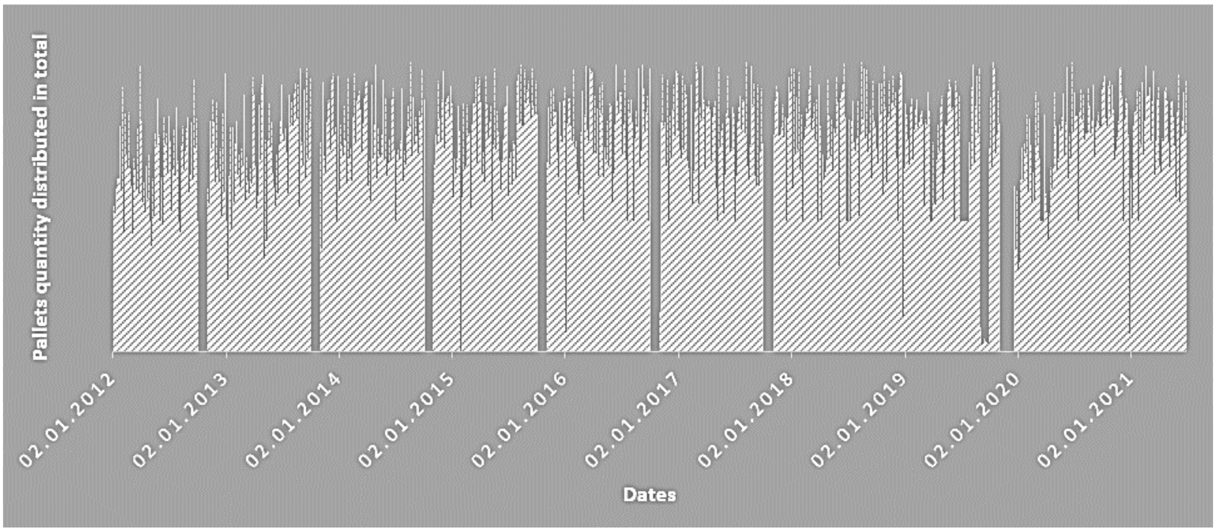

Figure 4. General data set.

Source: own elaboration.

The following data are analyzed according to the logic presented at figure 5.

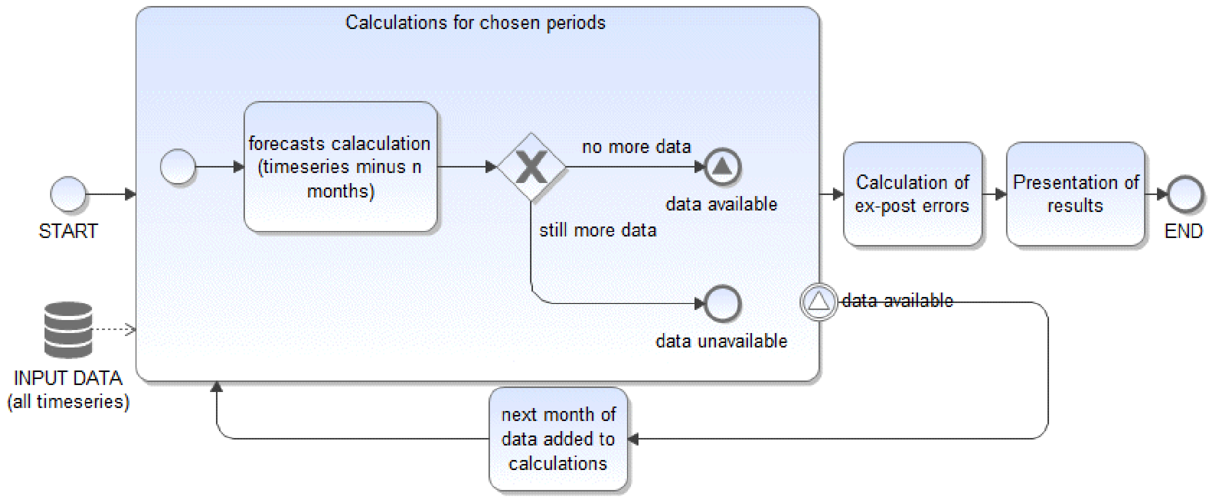

Figure 5. Data analysis general logic.

Source: own elaboration.

Analysis of chosen data set considers the dividing data into 6 sub sets and creating the forecasts for each of this data set. Creating a forecast is supported by the conception of adding the TMS data and creating the dashboard to present the results and support the decision makers in the field of transportation activity in the distribution network.

4. Results

The proposed tool is shown in figure 6 and assumes the usage of cloud-based real-time WMS data support. The user in this case uses the demand forecasting tool which is supported by TMS and WMS data to achieve the planned dashboard as a managerial tool for better coordination the transportation.

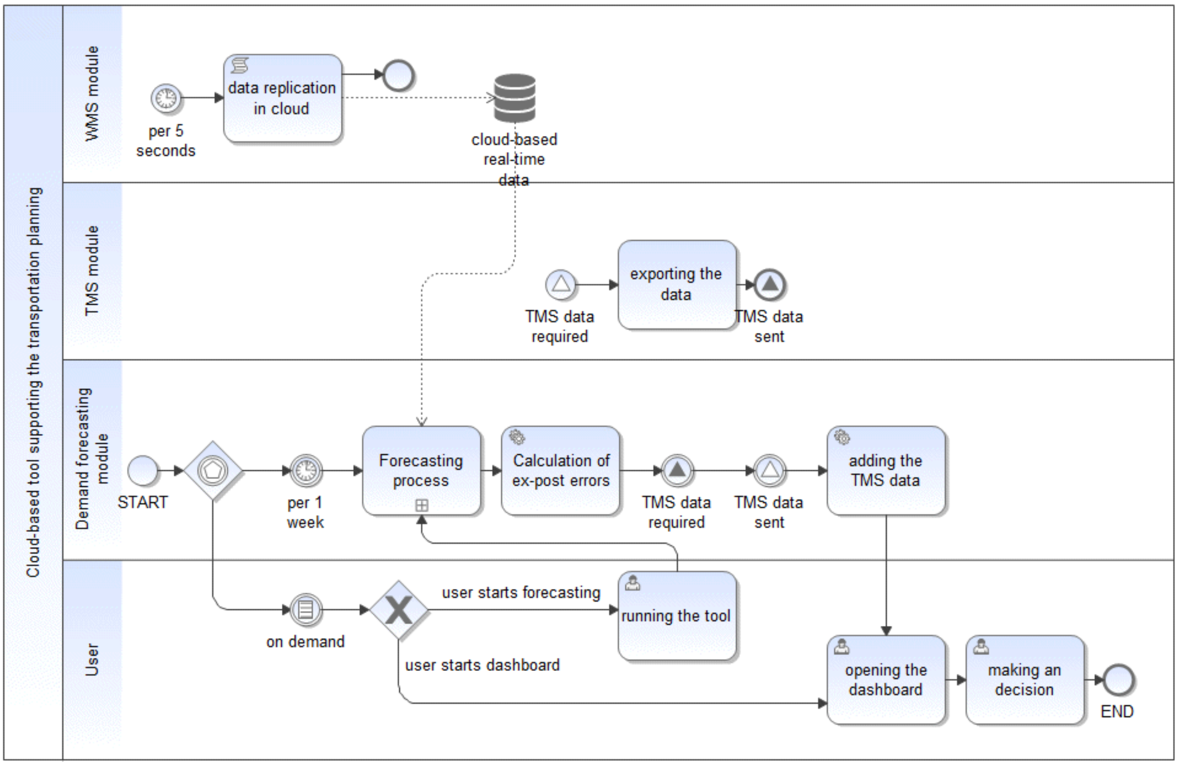

Figure 6. Transportation supporting tool – concept (simplified version).

Source: own elaboration.

Forecasts are updated once per week automatically or on demand by the user. TMS data support the final dashboard by the information about possible extensions in transportation capacity and giving information about the available vehicles. As a measure for accuracy the RMSE (root mean square error) was chosen. RMSE was calculated in the EUR1 (1200x800 [mm]) pallets dimension by using a following equation:

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(\hat{y}_i - y_i)^2},$$

where:

N – number of observations,

$\hat{y}_i$ – historical quantity of distributed pallets (pallets spaces in EUR1) in period I,

y_i – forecasted quantity of distributed pallets (pallets spaces in EUR1) in period i.

Results for six months were shown in table 1. Additionally, there is also shown the average accuracy for mentioned months. For simplification, each month is stated as four weeks.

Table 1.
Forecasting tool accuracy

Week	Accuracy [%]					
	Month 1	**Month 2**	**Month 3**	**Month 4**	**Month 5**	**Month 6**
1	6,59%	9,13%	10,14%	4,68%	4,92%	8,41%
2	9,34%	10,39%	2,10%	1,04%	10,11%	7,49%
3	5,96%	3,75%	1,93%	6,22%	12,02%	5,77%
4	8,00%	9,04%	6,96%	4,45%	4,79%	11,72%
Average accuracy [%]	7,47%	8,08%	5,26%	4,10%	7,96%	8,35%

Source: own elaboration.

The mean of the presented RMSE is equal to 6,17%, the median – 5,87%, and the standard deviation – 3,56% (it was presented in figure 7). Ranges of standard deviation up and down were calculated by adding or reducing the mean value by standard deviation.

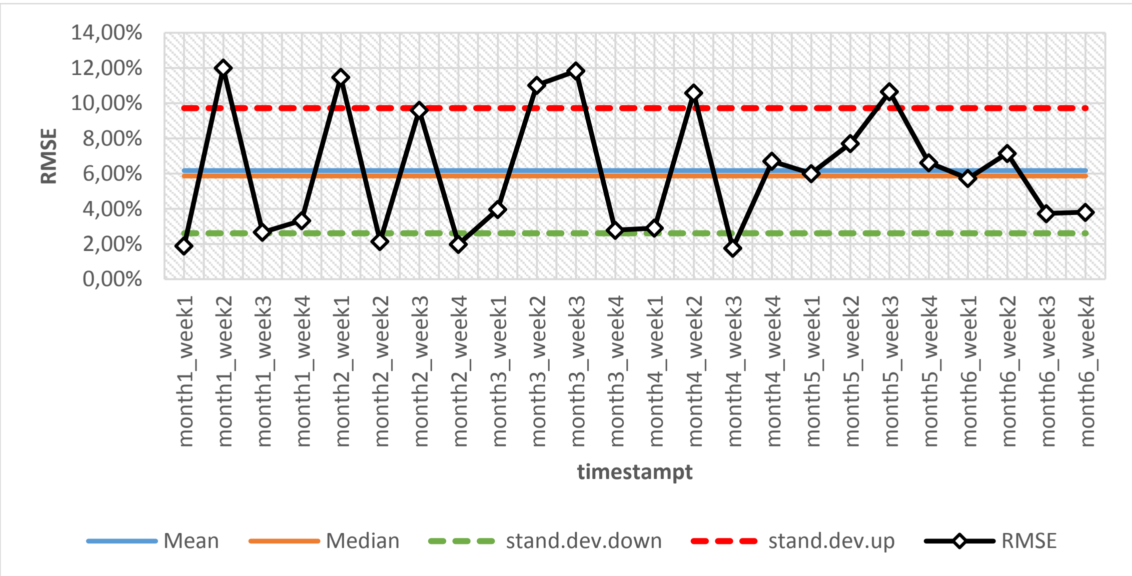

Figure 7. RMSE in the following periods.

Source: own elaboration.

Six of accuracy results were deviated for mean in the non-standard way, but generally it could be stated that accuracy is on relatively repeatable level. Forecasts could be additionally aggregated to the particular geographical region in the final dashboard. As a result, 3PL could be able to provide the early information about the future demand (in the pallets spaces point of view) in the individual areas of distribution. Part of dashboard which supports the transportation planning process by in-formation about forecasts is showed in the figure 8.

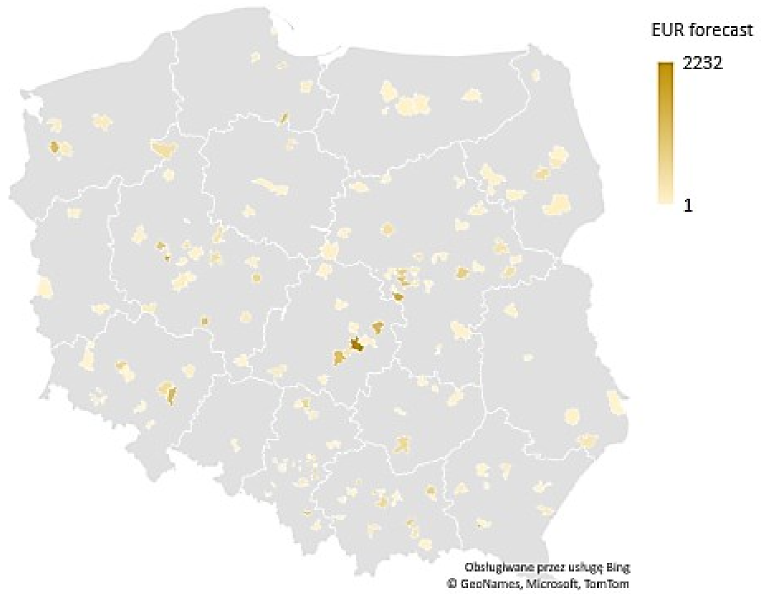

Figure 8. Forecasts information in the division to different geographical region.
Source: own elaboration in MS Excel & Bing.

Figure 7 shows the predicted demand information in EUR pallets quantities in the region of Poland. Thanks to this kind of solution the 3PL is able to modify the information about forecasts to knowledge about transportation demand.

5. Discussion

5.1. Transportation coordination by 3PL supported by demand forecasting

Demand forecasting tools could support coordination actions in the area of transportation in the distribution network. Transport operations, and in particular the ability to carry them out efficiently and flexibly, play a significant role in the coordination of the distribution network. The fact that logistic operators can coordinate and perform transport operations in distribution networks is influenced, among others, by the fact that these enterprises usually either have TMS class systems or have an easy ability to adapt such systems to their structures. Undoubtedly, these criteria must be considered when choosing an operator that will be able to coordinate the company's activities in the distribution network. Of course, not every operator who is able to provide transport services can coordinate the flows, but the ability to plan and organize transport operations is, according to the author, one of the necessary requirements for the implementation of the assumptions resulting from logistic coordination

On the other hand, in the logistics service industry, the most common issue is to keep the initiatives connected with environmental and sustainability issues (Cenrobelli et al., 2017), this, which was proven in much research, is leading to cost reduction and increasing sales (Marchet et al., 2014). In the author's opinion, the proposed solution also could have an influence on these two factors: sustainability and costs reduction. Better coordination in the area of transportation could allow to reduce the empty runs, increase the usage of truck loads and reduce the emergency transports

5.2. Is the 3PL enough for coordination?

Logistics operators (3PL) help the enterprise with meeting the increasingly growing customer requirements by generating added value in logistics processes. One of the most common barriers during development of collaboration with logistics operator are unreal requirements of enterprise which outsourced their processes to 3PL 3PL enterprise, because of their important meaning of nowadays markets and distribution networks, can contribute to shaping modern distribution networks, as well as perform more and more complex functions related to the provision of complementary services and often go beyond the logistics itself in order to gain a competitive advantage and provide their clients with appropriate conditions to co-create flexible and dynamic market systems in the form of reliable networks distribution. It is also to consider the role of 3PL, is it enough to talk about 3PL, or maybe we need to discuss of 4PL (fourth-party logistics)? 4PL is aimed more at strategic actions and knowledge (Multaharju, Hallikas, 2015) - logistics coordination could be also treated in this way. But in the author's opinion, the more practical case is to consider 3PL as a node able to take the function of logistics coordination in distribution networks. The reason for that is the larger number of 3PL in the market and the high probability of taking this function also by 4PL as the organization with the higher competency than 3PL, so if 3PL will be able to take this function there will be also some high probability that 4PL will be also able to do it.

5.3. Prospects for developing the conception

The usage of cloud infrastructure gives the possibility of achieving real-time data and accessibility to huge calculation power. The great access to data and prediction system could be also used for digital, computer models. It is also a good idea to support the cloud system with simulation software like Flexsim (Ashrafian et al., 2019) or to use additional Discreet Event Simulation or Digital Twins conception elements (Agalianos et al., 2020). In the case of transportation and logistics coordination could be consider as the models which support the 3PL by providing the models to check the transportation system in the real time and also could provide the interesting background for improving it.

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